

## ECSS in the eXtreme

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**Abstract.** The ESAC Gaia team engages in a form of eXtreme programming while the DPAC will follow a series of six month development cycles modeled on this approach. As a project within the European Space Agency the European Committee for Space Standardization (ECSS) standards are required. We present the bringing together of these realms.

### 1. Introduction

ECSS standards may be difficult to understand and without good tailoring are not well suited to the development of science processing software. Here we tell the DPAC story so far.

### 2. The Gaia Satellite and Science

The Gaia payload consists of three distinct instruments for astrometric, photometric and spectroscopic measurements, mounted on a single optical bench. Unlike HST and SIM, which are pointing missions observing a preselected list of objects, Gaia is a scanning satellite that will repeatedly survey in a systematic way the whole sky. The main performances of Gaia expressed with just a few numbers are just staggering and account for the vast scientific harvest awaited from the mission: a complete survey to 20th magnitude of all point sources amounting to more than one thousand million objects, with an astrometric accuracy of  $12\text{--}25\mu\text{as}$  at 15th magnitude and  $7\mu\text{as}$  for the few million stars brighter than 13th magnitude; radial velocities down to 17th magnitude, with an accuracy ranging from 1 to  $15\text{ km s}^{-1}$ ; multi-epoch spectrophotometry for every observed source sampling from the visible to the near IR.

Gaia is being constructed by EADS Astrium under contract from ESA and is scheduled for launch at the end of 2012. It is to spend five years at L2 carrying out its survey. The 35 meter antenna in Cebreros Spain (an occasionally New Norcia) will be used to downlink about 100 Terabytes of data.

### 3. The Astrometric Global Iterative Solution (AGIS)

The astrometry of Gaia is calculated from the multiple observations in different directions of the five years of the mission. The approach to this data reduction is a block iterative robust least squares fitting of the data as presented at the

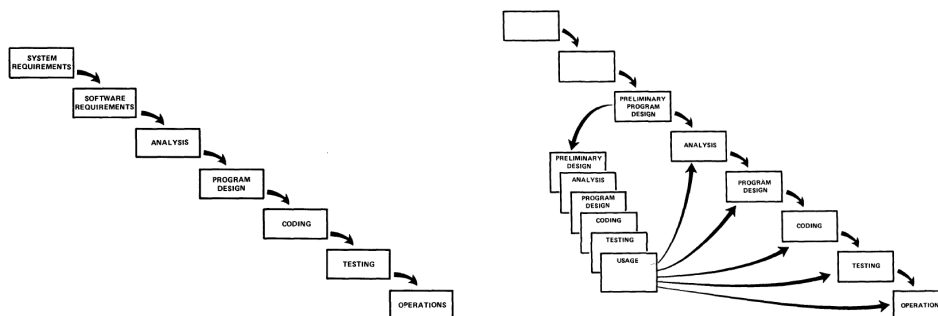


Figure 1. Royce's waterfall model (left) reproduced from Royce 1970. This is held to be the original waterfall approach but it is a scheme which Royce's paper claims is flawed. The right figure appears later in the same paper.

last ADASS (O'Mullane et al. 2007). Briefly objects are matched from the successive scans, attitude (three dimensional orientation of the satellite) and calibrations are updated. Next the object positions are solved followed by higher order terms usually referred to as global parameters (such as PPN  $\gamma$ ). This reduction provides us with : observed (proper) directions to a subset of *well-behaved* (primary) sources, attitude of the instrument as function of time and transformation from field angles to pixel coordinates. This requires selecting  $10^8$  of the  $10^9$  sources as input to the process and treating, iteratively, the  $10^{10}$  transits.

#### 4. Is development of Science software different ?

The author conducted a survey over one year of many large science developments O'Mullane 2005. This proved to be a most interesting study and concluded that science software development is indeed different to traditional software development due to the funding structure and general approach to leadership. This is in any case quite different to a satellite development project. Yet large organisations still wish to see developments like Gaia in a more traditional waterfall model. The approach to development within DPAC of using cycles and always having some working software leans much more toward the *Agile* techniques discussed here than traditional project management. Indeed these days there are few if any software companies remaining who follow the waterfall approach to development. The most lamentable thing of all is perhaps that Royce, attributed with the waterfall model, showed the waterfall approach in Royce 1970 (see Left Fig.1) as an example of the flawed way to do software development. Later in the same paper Royce (see Right Fig. 1) he argues one should "do it twice".

He points out the flaw in that it is a long time before implementation starts and real problems are seen. These real problems may fundamentally change requirements. All of these ideas are in line with *Agile* approaches. Our intention is to do it far more than twice - about ten times for DPAC. Even the preliminary AGIS went through several iterations before it was ready.

The perhaps the fundamental difference between science software development and satellite development is perhaps the risk element. Often for the software we may not know exactly how a particular problem will be solved or indeed if it may be solved. It would be a huge mistake to discard certain solutions simply to make a good plan (which is after all what most managers would like to see). Let us take some examples.

## 5. eXtreme development approach

No we do not all huddle around a single computer at ESAC but we have taken some useful ideas from the eXtreme programming field such as presented by Beck 1999. Planning is done on a monthly basis, stories are written and costed in points (where  $1point \approx 1/2day$ ). The cost is agreed as a team not set by *a manager*. Team members are also given points with which they *buy* the stories they wish to work on. Some stories of course must be *bought* first but generally team members should be able to have some story they would *like* to do in addition to the stories they *em* must do. All stories are entered in the XpTracker, a Twiki plugin designed for eXtreme programming.

Code, in general, is owned by the group - any developer may *improve* code. Code reviews are carried out frequently as a group where developers modify code and comments as well as raise issues. In this way we try to keep code in adherence with the agreed coding standards as well as keeping documentation valid and up to date. Such an open system only works with excellent test harness in place. We use JUnit to write tests and place emphasis on good test coverage (looking for 80 to 100%). CruiseControl is employed to regularly check out code, build it and run all of the JUnit tests. Developers must keep tests passing when any modification is made to the code. The AGIS system, for example, contains 100K lines of Java, 30K lines of test code and 90K lines of comments.

## 6. European Cooperation for Space Standardization (ECSS)

The European Space Agency (ESA) generally is more involved with satellite construction which follows a waterfall model of development. Indeed for hardware production there is little choice. Springing from this background the ECSS standards tell us how we should do a project, what documents should be produced when and, to some degree, what they should contain. The standards come as a long list of books for example : ECSS-E-10B Requirements , ECSS-M-30A Phasing, ECSS-M-40B Configuration Management, ECSS-Q-20B Quality Assurance, etc.

The also come with a set of reviews which should be held which hark back to the waterfall they are the System Requirements Review, the Preliminary Design Review, the Critical Design Review, the Qualification Review and the Acceptance Review. ECSS is considered applicable also to the ground segment software which includes the science processing software.

In reality ECSS is very flexible - perhaps too flexible, it must be tailored to a particular project. Clearly some of the ECSS is not applicable to software production so a *tailoring* must be undertaken. This outlines which parts of ECSS

will be used for the project and define to some extent the document tree (see Figure 2).

The usefulness of an eXtreme programming approach has been demonstrated for the AGIS software at ESAC. In general this sort of approach is very well suited to scientific software development. If this will work in the scaled up manner for DPAC does remain to be seen. Every project needs documentation and with a little effort the ECSS has been em tailored and a useful set of *standard* documentation outlined. Templates for these documents have been created. There remains considerable pressure toward more em traditional techniques for DPAC. Daily reading of Dilbert is recommended for sanity.

Beck, Kent, Addison-Wesley 1999, *Extreme Programming Explained: Embrace Change*

O'Mullane, William et al, Proceedings of ADASS XVI 2007, *Gaia Data Processing Architecture*,

O'Mullane, William, Study Report 2005, *A study of Some Large Scientific Processing Systems and Applicability to Gaia*,

Royce, Winston, Proceedings of IEEE WESCON August 1970, *Managing the Development of Large Software Systems*,